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Fatty Infiltration in Multifidus Muscles and its Association With Spinal MRI Findings

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Abstract

Background: The present cross sectional study was conducted to evaluate the relation between fatty infiltration (FI) in multifidus muscles and spinal MRI findings among patients who referred to Sina Athar and Kosar imaging centers of Shahid Beheshti University of Medical Sciences

Methods: Discovertebral and facet joint degenerative changes, intervertebral foraminal narrowing, disk herniation and central canal stenosis in all lumbar levels and FI in multifidus muscles at the level of L5 vertebra were assessed on magnetic resonance imaging (MRI) studies of 333 patients, and correlation of these MRI changes with FI was identified.

Results: Among 333 patients (174 female), whose data were analyzed, 316 patients mentioned a positive history of back pain. We observed a significant relation between female sex and higher age with degrees of multifidus FI in L5 level. No significant association was found between the existence of back pain and the rate of multifidus FI. There was a significant negative relation between the activity level and the amount of multifidus FI. Considering weekly exercise level and hours of computer use, this association was not observed. Evaluating the relation between end plate and facet joint degenerative process and also neuroforaminal stenosis with multifidus FI, a statistically significant relation was noted. This correlation was not observed for central canal stenosis.

Conclusion: We concluded that the degree of multifidus FI was remarkably higher in female gender, older ages and subjects with more sedentary lifestyle. Moreover, a significant correlation existed between abnormal MRI imaging findings (degenerative process, discopathies, foraminal stenosis) and multifidus FI.

Keywords: Low back pain; Fatty infiltration; Multifidi muscles.

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Introduction

Low back pain is one of the most common musculoskeletal disorders. About 80% of human beings experience at least one episode of low back pain throughout their lives.[1,2] The prevalence of this disorders is reported about 84% among adult population.[3] Back pain is estimated to be the most prevalent chronic disease in people younger than 65 years old. As to considerable financial burden of the disease on public health system, researchers have always been concerned about the prevention and treatment of low back pain.

Two main groups of muscles forming the lumbar paraspinal are: the transversospinales, which include the multifidi; and the more laterally located erector spinae, which consist of the longissimus and iliocostalis muscles.[4-6] These muscles have an important role in spinal stability and trunk movements.[7,8] The multifidi are tiny segmental stabilizers of the spine. Given their small size, they cannot generate enough force for spinal extension, so they act to control the lumbar flexion. It is hypothesized that their most important function is of a sensory organ in the spine.[9] Owing to the predominance of muscle spindles, multifidi provide proprioceptive input from the spinal column to the nervous system. Based on their function, any injury to these muscles can lead to impairments in proprioception and, consequently, impaired stability of the vertebral column which can, in turn, predispose the spine to more injury and pain. Theoretically, multifidi muscles atrophy can eventuate in back pain. Up to now, the exact cause and effect relationship between these two events has not been clarified. Whether muscular atrophy leads to back pain or inactivity caused by pain results in muscular atrophy is still unclear. In other words, they could simply be parts of a vicious cycle of pain, inactivity and muscular atrophy.[9,10]

In the past few years, increasing attention has been paid to the paraspinal musculature. Particularly, researches have been focused on multifidi muscles. It seems that the correlation between muscular atrophy and fatty infiltration (FI) of multifidi and back pain is not ignorable.

Unfortunately, the results in this area are inconclusive. Mannion AF is reported fiber distribution changes and reduced muscle size in back pain group. Nonetheless, the abnormalities were generally non-specific and affected a small proportion (less than 10%) of fibers. He concluded that the extent of abnormalities in the musculature most likely depends on the patients' age, symptom duration, exercise performance and activity levels prior to the onset of pain and also the severity of their pain induced inactivity.[11]

Nowadays, histological evaluation is extensively substituted by modern imaging techniques such as computed tomography (CT) scan and magnetic resonance imaging (MRI) which can provide noninvasive, precise and reproducible information about cross sectional area and density of muscles.[12] Muscular atrophy can be measured by a reduction in cross sectional areas. Also, a reduction in density or an increase in T2 signal intensity reflects FI of muscles.

The reliability of these techniques for measuring the FI of paraspinal muscles is acceptable.[13,14]

Considering this uncertainty, we conducted the current study to evaluate the association between FI in multifidus muscles and spinal MRI findings among patients who referred to Sina Athar and Kosar imaging centers of Shahid Beheshti University of Medical Sciences

Materials and Methods

A total number of 400 patients who attended our imaging centers, entered this cross sectional study. The image acquisition was performed in Sina Athar and Kosar imaging centers of Shahid Beheshti University of Medical Sciences. Through a table of random numbers, participants were selected among patients who were referred to undertake lumbosacral MRI. Patient selection was conducted in the time interval of May 2013 to May 2014.

Subjects with a history of lumbosacral surgery or other minimally invasive procedures of the spine, malignancy, radiation, spinal trauma and spinal deformities such as kyphoscoliosis were excluded from the study. Finally, 333 subjects entered the analysis.

Patients' information including gender, age, height, weight, back pain, daily workload, weekly exercise hours and rate of computer work were obtained through a questionnaire. Having received enough explanation about the process, the patients signed a consent form. The study met the standards for human experiments set by the Declaration of Helsinki. Daily workload was defined as follows: complete sedentary, partial sedentary, partially active and completely active. Weekly exercise and daily computer use were defined as following: none, less than 2 hours, between 2-4 hours, between 4-6 hours and more than 6 hours per week.

All MRIs were assessed by an experienced radiologist. The radiologist did not meet the patients and was completely blind about their history and life style information.

MRIs were assessed in all lumbar levels (L1-S1). The following parameters were searched for, and if existing, graded into mild, moderate and severe (Figure 1): end plate degenerative changes, right and left facet joint degeneration, central canal stenosis, intervertebral foraminal narrowing (left and right), nerve roots compression, disc herniation (protrusion, bulging, extrusion) and FI either in left or right multifidus muscle at L5 level. To measure the FI, signal intensity variations were used. The grading system of FI was as follows: replacement of less than 10% of muscle area by fat was considered normal, muscle area replacement between 10% and 50% was slight and more than 50% replacement was severe.[15]

The MRI method was: T1-weighted spine echo 300/26 repetition time/echo time. 120 × 256 matrix, 280 mm field of view, 4 mm section thickness, low field 1.5T MRI + body spine surface coil.

Data Analysis

For expression of findings, charts and tables were used. Mean and standard deviation (SD) were used to express the continuous variables. For categorical variables, the

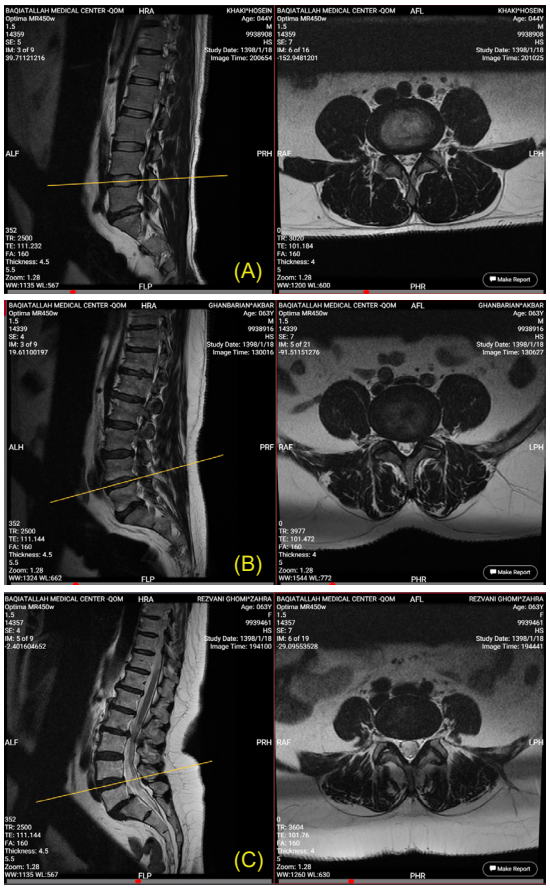

Figure 1. Axial T2W at L4-L5 (A) level-normal, (B) level-mild and (C) level-severe.

frequency and percentage were reported. Continuous and categorical variables were compared using the independent sample t-tests and chi-squared test, respectively. Data analysis was performed using SPSS version 20, and the level of significance was set at 0.05.

Results

A total number of 400 (211 women and 189 men) patients who attended the imaging centers entered the study. After the evaluation of patients' history, 67 subjects were excluded and finally 333 (174 women and 159 men) patients' data were analyzed. Regarding the history of low back pain, 316 patients mentioned a positive history and 17 did not. No significant difference was found between prevalence of low back pain in men (n = 151) and women (n = 165). There was no significant positive association between low back pain and the rate of multifidus FI.

We observed a significant relation between gender and degrees of multifidus FI (P<0.0001). The prevalence of FI was remarkably higher in female subjects [78.7% (n = 136) vs. 43% (n = 38) in males].

A positive association was also found between age and rate of FI (P < 0.0001). The mean age of patients with slight to severe FI was 51.2 years, in contrast to patients without FI whose mean age was 36.6 years.

There was a significant relation between activity level and amount of multifidus FI (P = 0.01). In other words, patients with FI were considerably less active. For more details, only 13.5% (n = 27) of subjects with FI (n = 205) were completely active; whereas, this measure was 27.9% (n = 36) in the group of subjects without FI (n = 128). This association was not observed between weekly exercise level and FI in multifidus muscle. Table 1 shows the association of patients' characteristics with multifidus FI.

We did not find any significant correlation between hours of computer use and the amount of multifidus FI (Table 1).

Considering the relation between end plate degenerative process and FI, a statistically significant relation was found. This correlation was observed in all L1 through S1 levels (P < 0.0001). Furthermore, at L1 through S1 levels, we found a remarkable correlation between facet joint degeneration and FI (P < 0.005) (Table 2).

With regard to the lumbosacral central canal and intervertebral foraminal stenosis, the results were as follows:

Although in the presence of central canal stenosis the rate of FI was higher, a significant relation was observed only at L2-L3 level (P < 0.007) (Table 3). On the other hand, foraminal stenosis and FI showed a significant correlation at all spinal levels (P < 0.05).

Evaluating discopathies (bulging, protrusion and extrusion) and their relation with FI, a significant association was detected just at the L5- S1 level (P < 0.02) (Table 4).

Finally, we noted a significant association between nerve root compression and FI at right L3- L4 [15.5% (n = 32) severe FI vs. 38.1% (n = 48) normal FI] and bilateral L4-L5 levels [43.5% (n = 89) severe FI vs. 60% (n = 77) normal FI] (P < 0.03).

Table 1. Characteristics of the Study Participants by Grading of Muscle Fat Infiltration at the L5-S1 Levels

Variables	Normal Fatty Infiltration n=128	Slight/Severe Fatty Infiltration n=205
Sex		
Male	90 (57.0)	69 (43.0)
Female	38 (21.7)	136 (78.3)
Age	36.6 (11.0)	51.2 (14.9)
Patient activity		
No daily activity	63 (48.0)	13 (9.9)
Heavy daily activity	35 (27.9)	19 (13.5)
No weekly exercise	78 (61.0)	131 (64.0)
>6 h weekly exercise	1 (0.8)	2 (1.0)
No daily computer use	46 (35.9)	88 (43.2)
>6 h daily computer use	0 (0)	4 (2.3)

Data were reported as mean (SD) or n (%) for continuously and categorically distributed variables, respectively.

Table 2. Relation of Fatty Infiltration in Multifidus Muscles With Facet Degenerative Changes

Spinal Level	Side	Normal Fatty Infiltration n=128	Slight/Severe Fatty Infiltration n=205
L1-L2	Rt facet DJD	62 (48.8)	53 (25.9)
	Lt facet DJD	61 (48.2)	53 (25.9)
L2-L3	Rt facet DJD	73 (57.0)	74 (36.0)
	Lt facet DJD	72 (56.5)	74 (36.0)
L3-L4	Rt facet DJD	79 (61.7)	85 (41.7)
	Lt facet DJD	78 (62.1)	85 (41.7)
L4-L5	Rt facet DJD	84 (65.8)	87 (42.6)
	Lt facet DJD	86 (66.0)	88 (43.0)
L5-S1	Rt facet DJD	75 (58.7)	75 (36.6)
	Lt facet DJD	76 (59.0)	75 (36.6)

All values are No. (%).
DJD: degenerative joint disease ; Lt: left; Rt: right.

Table 3. Relation of Fatty Infiltration in Multifidus Muscles With Canal Stenosis

Spinal level	Normal Fatty Infiltration n=128	Slight/Severe Fatty Infiltration n=205
L1-L2 canal stenosis	18(14.1)	9(4.6)
L2-L3 canal stenosis	35(27.8)	15(7.5)
L3-L4 canal stenosis	46(36.4)	42(20.8)
L4-L5 canal stenosis	60(47.4)	83(40.8)
L5-S1 canal stenosis	51(40.1)	71(34.7)

All values are No. (%).

Discussion

In the current study, we obtained a significant correlation between multifidus FI and older age, female gender and lower levels of activity. These findings support the findings of other researches. In a retrospective study by Chen et al

Table 4. Relation of Fatty Infiltration in Multifidus Muscles With L5-S1 Discopathies

	Bulging Disc	Paracentral Protrusion	Central Protrusion	Paracentral Extrusion	Central Extrusion
Normal fatty infiltration (n=128)	59 (45.6)	25 (20.2)	8 (5.9)	2 (1.7)	2 (1.7)
Slight/severe fatty infiltration (n=205)	143 (70.6)	76 (36.8)	12 (5.9)	15 (7.4)	8 (4.4)

All values are No. (%).

to compare the morphometric parameters of Psoas major and multifidi muscles in lumbar spinal stenosis patients, it was shown that the younger male patients exhibited a larger Psoas cross sectional area than the older or female subjects.[16] Moreover, higher multifidus FI was noticed in older patients. Lumbar spinal stenosis patients in the high functional performance group exhibited a significantly larger Psoas cross sectional area and lower degrees of multifidus FI.

The natural course of age-related lumbar paraspinal muscle changes during adulthood and effect of lifestyle factors (e.g., physical activity levels at work and leisure, body mass index (BMI), and existence of low back pain) was evaluated in a study by Fortin et al.[17] During a 15-year period of follow-up, paraspinal muscles exhibited a decrease in cross sectional area and an increase in FI. Age and BMI were found to be significantly associated with overtime paraspinal muscle changes. Nevertheless, there was no relation between paraspinal muscle changes and the level of physical demands at work or leisure or low back pain history.

We did not observe any association between chronic low back pain and multifidus FI. As previously mentioned, whether paraspinal muscle variations (e.g., size, composition) are correlated with low back pain has been the subject of a long-lasting controversy. Fortin et al conducted a population-based longitudinal study addressing this challenge. Their study provided evidence that MRI founded paraspinal muscle changes had a limited, if not, role in the short- and long-term prediction of low back pain in men.[18] In contrast to this finding, in a study of 31 cases with chronic low back pain, Wu WW et al, identified that chronic low back pain was one of the most important sources of multifidus muscle atrophy and FI. They concluded that the duration and severity of pain were positively correlated with the severity of multifidus muscle atrophy.[19] Maybe this dilemma needs more studies with more precise planning and elimination of confounding factors to be solved.

There are few studies focusing on disc herniation and its impact on paraspinal muscles. Fortin et al investigated the asymmetry in size and composition of the multifidus and erector spinae in 33 patients with L4-L5 posterolateral disc herniation.[20] They also determined the association of symptom duration with the degree of asymmetry. Having no correlation with symptom duration, they found greater FI on the side and at the spinal level adjacent to the disc herniation. This study's findings are in line with ours.

As it was mentioned earlier, we could not find a remarkable relation between weekly exercise or hours of computer use and multifidus FI. Again, the results of studies in this area are inconclusive. In a study by Danneels et al, general stabilization exercises and dynamic intensive lumbar resistance training had no significant effect on the cross sectional area of lumbar multifidus muscle in patients with chronic low back pain.[21] In contrast, other studies have shown significant increases in the cross sectional area after a period of dynamic extension exercises.[22] Hides et al found that localized physical training restored the size of the multifidus muscle in patients with acute low back pain.[23] Ikezoe et al evaluated the trunk muscle thickness of active and inactive elderly population and compared them to the youth. The thicknesses of all muscles in the dependent elderly group was significantly smaller than that in the young group, whereas there were no differences between the dependent elderly and independent elderly groups in the muscle thicknesses of the rectus abdominis and internal oblique muscles.[24] In another study by Hides et al, on the effect of 8 weeks of bed rest on healthy subject's spine, they concluded that bed rest resulted in selective atrophy of the multifidus muscle.[25] In study of Kjaer et al, those adults who reported being active in sports or having heavy physical work, had statistically less severe FI.[26]

In our study, there was a significant association between multifidus FI and lumbosacral degenerative changes (including end plate and facet joints). Kjaer et al, showed that multifidus FI tends to happen more frequently in areas with degenerative process.[26] Furthermore, considering intervertebral foraminal stenosis and disk changes, this correlation was also noticed. In another study by Keshavarz et al, a significant correlation between back pain and FI in multifidus muscles and degenerative findings on MRI was observed.[27]It can be concluded that increased abnormal imaging findings in lumbosacral MRI accompanies more severe degrees of multifidus FI.

One major limitation of the current study is the significantly higher number of low back pain patients, compared to normal subjects (316 subjects with low back pain vs. 17 subjects without low back pain). This disproportion can be a source of bias.

In conclusion, it seems that paraspinal muscles deserve more attention. Maybe, allocating an established place in routine MRI reports to description of these muscles' condition is of great merit.

Conclusion

This study suggests that the degree of multifidus FI is remarkably higher in female gender, older ages and subjects with more sedentary lifestyle. Moreover, a

significant correlation exists between abnormal MRI imaging findings (degenerative process, discopathies, foraminal stenosis) and multifidus FI.

Conflict of Interest Disclosures

The authors declare that they have no conflict of interests.

Ethical Statement

Since the study was an observational one with no intervention on subjects and MRI was ordered by other practitioners, no ethical consideration was needed to be applied.

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